ARMORED FORCE MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

PROJECT NO. 2 - HIGH TEMPERATURES IN TANKS

Final Report On

Sub-Project No. 2-29 - Test of Truck, 3/4 Ton, Refrigerated Ambulance

Project No. 2-29 INFORMATION COPY May 15, 1943

ARMORED FORCE MEDICAL RESEARCH LABORATORY
Fort Knox, Kentucky

Project No. 2-29
451.8 GNOML

May 15, 1943

1. PROJECT: No. 2 - High Temperatures in Tanks. Final Report on: Sub-Project No. 2-29 - Test of Truck, 3/4 Ton, Refrigerated Ambulance.

a. Authority - Letter Commanding General, Army Ground Forces, Washington, D. C., 451.8/39 - GNRQT-8/34292, dated March 14, 1943, and 1st Indorsement, Commanding General, Headquarters Armored Force, Fort Knox, 451.8 (3-14-43) GNOHD, dated March 17, 1943. (See Inclosure # 1)

b. Purpose - To determine the suitability of subject ambulance (Army Serial No. 77974) for use in hot climates.

2. DISCUSSION:

Methods: Subject ambulance was tested in the Laboratory Hot Room under two simulated climatic conditions:

a. Desert, with diurnal variation in radiant heat, provided by a bank of infrared lamps on the ceiling, and with temperature changes approximating an average day in the desert.

b. Jungle, with moderately high temperature and extreme moisture content of the air, but without radiation.

Air temperatures were taken periodically inside and outside the vehicle, and surface temperatures were measured on the top and sides, both externally and internally.

Details of procedures and results are given in the appendix.

3. CONCLUSIONS:

a. The refrigerating system in subject ambulance possesses adequate cooling capacity for use in desert climates.

b. Refrigerating system in this ambulance does not possess adequate cooling capacity for use in tropical climates.

c. For successful operation, rear doors and bulkhead doors separating driving compartment from patient compartment must remain closed. Insulation of bulkhead doors would be desirable.

d. Operation of intake fan on roof of patient compartment is optional with occupants.

e. Control of window and cowl ventilator opening in driving compartment is optional with forward occupants and does not affect the cooling.

4. RECOMMENDATIONS:

a. That subject vehicle be considered adequate for transportation of casualties in climates where ambient temperatures above 100°F with low humidity are encountered.

b. Greater refrigeration capacity be provided for use in tropical climates where high relative humidities are encountered.

Prepared by:
1st Lt. Robert H. Walpole, Sn-C

APPROVED Willard Machle
WILLARD MACHLE
Colonel, Medical Corps
Commanding

2 Incl.
1 - Letter of Authority
2 - Appendix, with Tables 1 & 2, and Charts 1, 2 & 3

HEADQUARTERS
ARMY GROUND FORCES
ARMY WAR COLLEGE
Washington, D. C.

451.8/39-GNRQT-8/34292
(2-22-43)

Mar. 14, 1943.

SUBJECT: Test of Truck, 3/4-Ton, Refrigerated Ambulance

TO : Chief of the Armored Force, Fort Knox, Kentucky

1. Inclosed herewith is a copy of the Desert Warfare Board report of test of the Truck, 3/4-Ton, Refrigerated Ambulance.

2. Instructions have been issued to the President, Desert Warfare Board to ship the subject vehicle to the Armored Force Medical Research Laboratory, Fort Knox, Kentucky and to inform your headquarters of date of shipment thereof.

3. It is requested that the subject vehicle be tested through the facilities of the Armored Force Medical Research Laboratory to determine its suitability for use in hot climates, and upon completion of tests report thereof be submitted to this headquarters in sextuplet.

By command of LT. GEN. McNAIR:

/s/ J. R. Dryden
J. R. DRYDEN,
Lt. Col., A. G. D.,
Asst. Ground Adj. Gen.

1 Incl.
Rpt of tst of Truck, 3/4-Ton,
Refrigerated Ambulance, P-61-2,
dt'd 2-22-43.

Incl. #1

451.8 (3-14-43) GNOHD 1st Ind.

HEADQUARTERS ARMORED FORCE, Fort Knox, Kentucky, March 17, 1943.

To: Commanding Officer, Armored Force Medical Research Laboratory, Fort Knox, Kentucky.

For compliance.

By command of Lieutenant General DEVERS:

/s/ C. M. Wells
C. M. WELLS
Lieut. Colonel, A. G. D.,
Assistant Adjutant General.

1 Incl:
n/c

APPENDIX

TEST CONDITIONS:

1. Test I to IV, inclusive: Dry desert atmosphere, with variation in radiant heat approximating the solar heat load (See Fig. 1) and changes in air temperature simulating the average diurnal temperature curve for the California desert.

Radiation was provided by a bank of heat lamps mounted below the ceiling of the hot room and the diurnal cycle was obtained by hourly changes in the number of lamps in operation. The intensity of radiant heat reached a maximum of 320 Btu per sq. ft. per hour, which corresponds closely to the intensity of solar radiation at midday on July 21st at latitude 30°N. Relative humidity was approximately 25%.

Test I - Test vehicle with cooling equipment not operating. No outside air movement and no mechanical ventilation of vehicle. Purpose of test: To compare the insulation of subject vehicle with that of a standard ambulance.

Test II - A standard ambulance tested under the same conditions as vehicle in Test I.

Test III - Test vehicle with refrigeration system in operation. No outside air movement.

Test IV - Test vehicle with refrigeration system in operation. Outside air velocity approximately 10 mph to simulate wind or movement of the vehicle.

2. Test V - Continual application of radiant heat equal to the maximum solar radiation at noon, with correspondingly nigh maximum temperature. Test vehicle with refrigerating system in operation. Outside air movement of approximately 10 mph. Five "patients" in ambulance. Purpose of test: to determine capacity of refrigerating system in relation to the maintenance of comfortable atmospheric conditions inside vehicle with maximum heat load and with relatively dry air.

3. Test VI - Continual exposure of vehicle to an atmosphere simulating extreme jungle conditions, with high relative humidity. Test vehicle with refrigerating system in operation. Five "patients" in ambulance. Purpose of test: to determine capacity of refrigerating system in relation to comfort of patients when the moisture content of the outside air is nigh.

RESULTS:

a. The relative degree of insulation of test vehicle as compared with standard ambulances is shown by the comparative temperature-rise curves of

inside air when the two vehicles were subjected to the same outside air temperatures and equal radiant heat loads (Fig. 2). In the test vehicle the inside temperature rose to a maximum of 22°F above that of the outside temperature whereas in the standard ambulance, the maximum inside temperature was more than 40°F above that of the outside air.

b. Refrigerating effect. The cooling capacity of the refrigerating system is also shown in Fig. 2. Under the same test conditions as above but with the refrigerating system in operation (Test III) the inside air temperature rose to a maximum of 88°F while the outside temperature increased to 105°F. By means of the cooling system the air temperature within the ambulance was maintained at least 20°F below the outside temperature. Conditions were even more favorable with outside air movement. The effect of this was to increase the heat loss from the hot surfaces of the vehicle to the outside air and, as a consequence, the load upon the refrigerating system was reduced. As a result, the inside air temperature was maintained at a lower level than with still outside air. The beneficial effect of the cooling system is further emphasized by the marked drop in temperature when the refrigeration system was turned on. During the first hour no cooling was provided and the inside air temperature rose to a level of 7° above outside temperature. Within an hour after starting the refrigerating apparatus, however, the temperature within the ambulance had dropped 22°F.

Outside surface temperatures are tabulated for Test I to IV in Table 1. The beneficial effect of outside air movement is seen by comparing the values for Test IV with the others. The maximum skin temperature was 124°F, whereas with still air the temperature rose to 170°.

c. Comparative performance of refrigerating system in desert and jungle atmospheres. The performance of the refrigerated ambulance in the desert atmosphere with continued exposure to maximum solar radiation and air temperature is shown in Fig. 3. Five "patients" remained in the vehicle for five hours. During this period the outside temperature averaged 114°F while the surface temperature was 140-150°F. The air temperature within the vehicle was reduced to 85° after approximately one hour of operation of the cooler and the relative humidity was maintained at about 40%. The "patients" were comfortable throughout the test.

In comparison with the foregoing, conditions were not comfortable during continuous exposure to jungle heat. Atmospheric conditions within the ambulance are given in Table 2. With an outside dry bulb temperature of approximately 110°F, wet bulb temperature of 103°F and 80% relative humidity, the inside atmosphere averaged 100° dry bulb, 94° wet bulb and 80% relative humidity. The test conditions were in excess

of those encountered in jungles but the results, in comparison with those obtained with desert conditions, illustrate the important point that a greater refrigerating capacity is required in the jungle than in the desert in spite of the higher dry bulb temperature in the latter situation. The explanation is that the total heat of the air is measured by the wet bulb rather than the dry bulb temperature. In the jungle, wet bulb temperatures above 85° may be encountered whereas in a hot arid climate the wet bulb temperature rarely exceeds 80°. Furthermore, in the latter case, the evaporation of sweat aids in cooling the body so that a higher dry bulb temperature can be tolerated.

Mechanical features and durability of the refrigerating system were not considered in these tests, the purpose being only to determine cooling capacity in relation to simulated desert and jungle conditions.

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TABLE 1

AVERAGE EXTERNAL SURFACE TEMPERATURE OF
REFRIGERATED AMBULANCE (#779L4) AND STANDARD AMBULANCE (#711Q46)
TESTS I, II, III, IV

Simulated Sun Time, Hours	SURFACE TEMPERATURES, DEG. F. Test I	Test II	Test III	Test IV
0730	77	85.7	74.7	
0745	93.7	111	105.3	
0800	104	115.3	106.7	
0815	105.3	121	110.7	
0830	106	118.3	112.3	
0845	113	121.3	130.7	
0900	113	124	140	
0915	120.3	125.3	138.7	
0930	122.7	126.3	136.7	
0945	--	140.7	138.3	
[illegible]	[illegible]	[illegible]	[illegible]	
1015	139	142.3	149	
1030	141.3	151.7	153	
1045	147	158	155.7	
1100	150.3	160.3	156.7	
1115	—	161	160	
1130	155.3	166.7	161	
[illegible]	—	[illegible]	[illegible]	
1200	161.3	172.3	160.3	
1215	159.7	173.3	163.3	
1230	154.7	172	162.3	
1245	152	169.3	161.7	
1300	—	169.3	161.7	
1315	146.7	169	147.3	
1330	147.3	171.3	115	

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TABLE 2

WET BULB, DRY BULB, RELATIVE HUMIDITIES, BOTH INSIDE AND OUTSIDE,-FOR TROPICAL TEST OF REFRIGERATED AMBULANCE

Time	Patient Compartment			Outside Room Air		
In Minutes	D.B.	W.B.	% R.H.	D.B.	W.B.	% R.H.
0	104	99	84	103.6	103.6	94
5	101	94	77			
10	100	94	79.5			
15	100	94	79.5			
20	100	95	83	108.8	102.7	82
25	100.5	95	81			
30	100.7	94.7	80			
35	101.6	96	81			
40	101	94	76.5	111.7	104.3	78
45	100.5	94	78			
50	100.5	94.5	80			
55	100.5	94.5	80			
60	100.5	95	81	110.2	104.7	85

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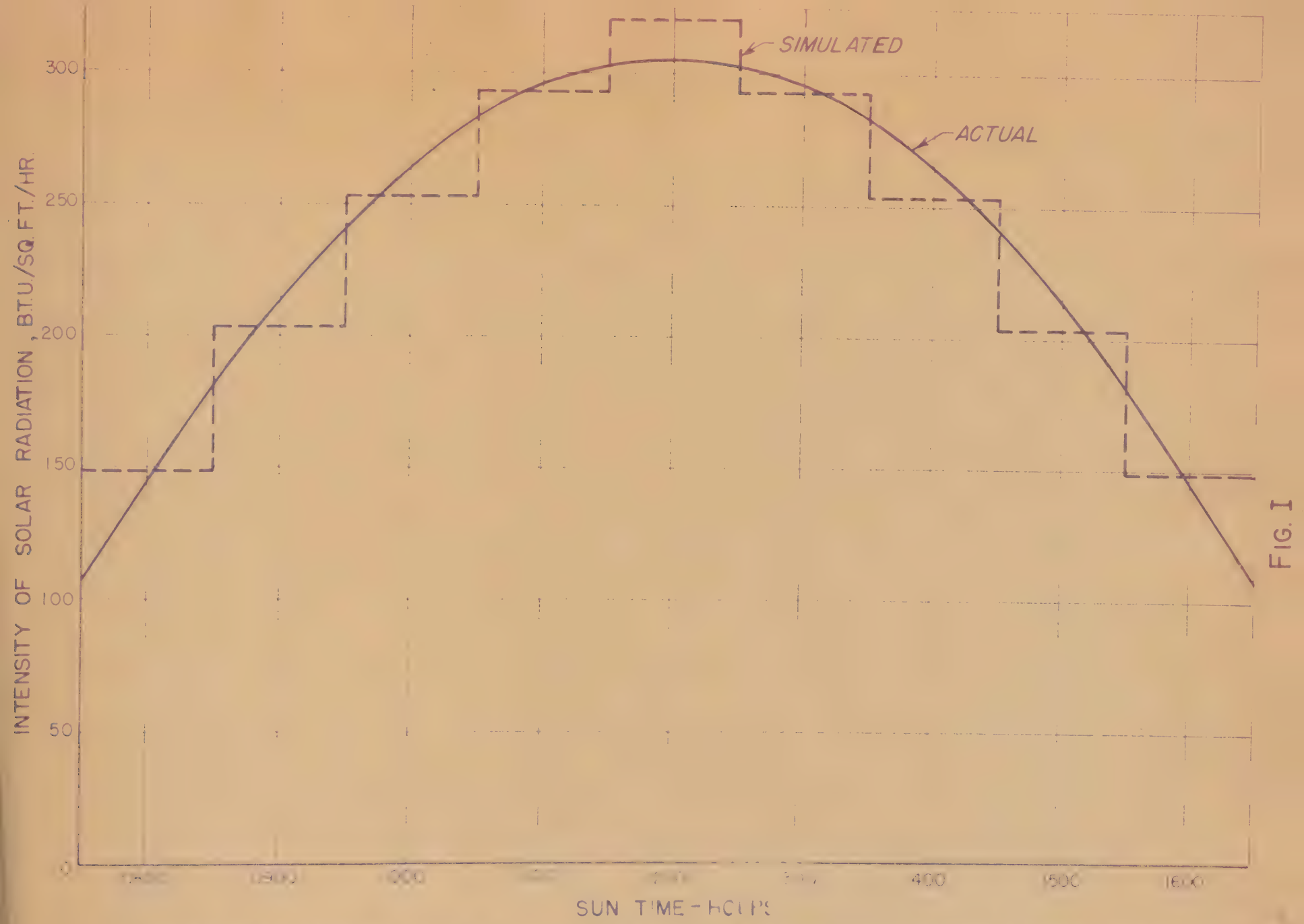

FIG. I

SOLAR RADIATION IMPINGING AGAINST A HORIZONTAL SURFACE FOR 30 DEGREE LATITUDE
JULY 2
ACTUAL AND SIMULATED CONDITIONS
FIG. I

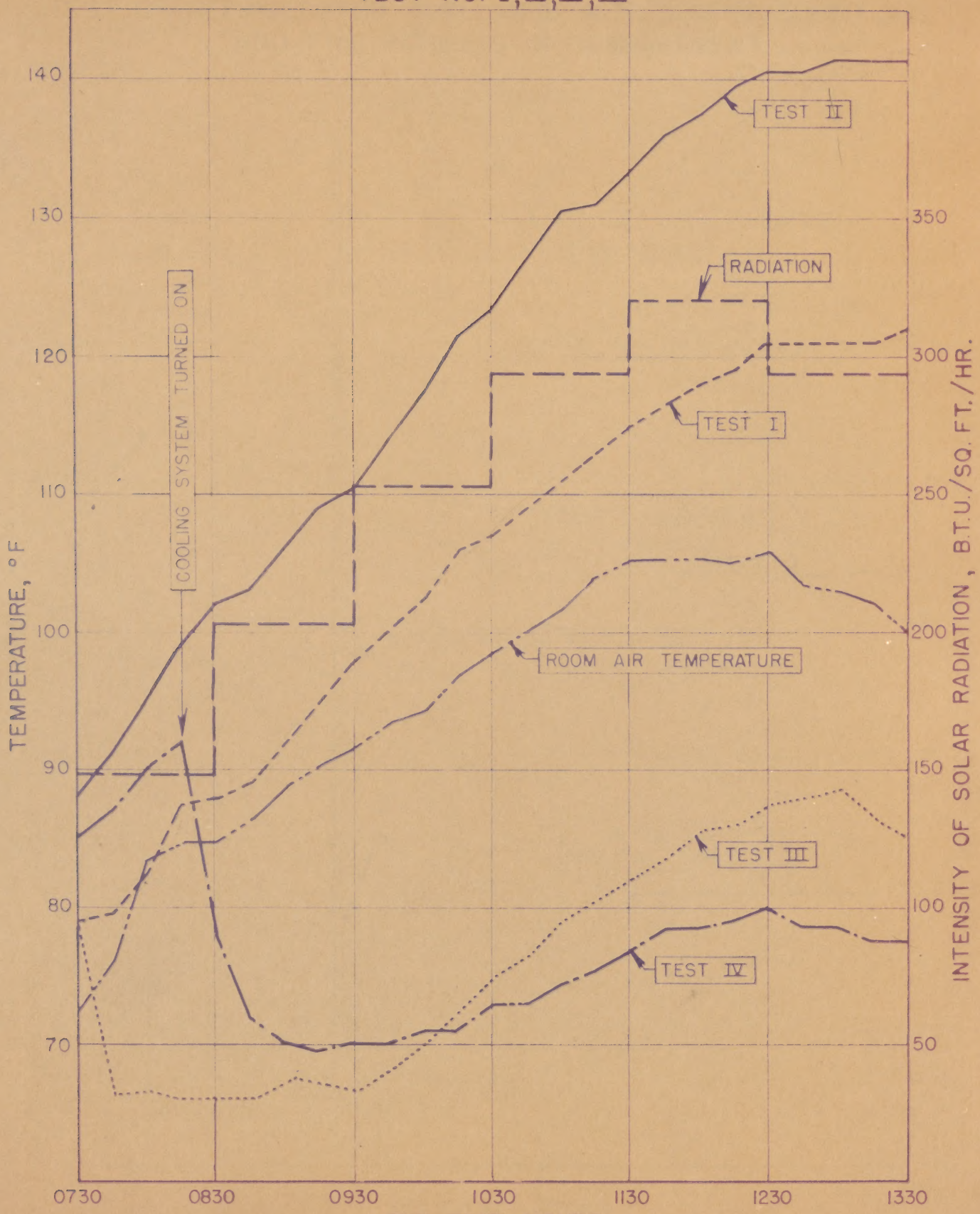
AIR TEMPERATURES
GROUP ONE
TEST NO. I, II, III, IV
TEMPERATURE, °F
INTENSITY OF SOLAR RADIATION, BT.U./SQ. FT./HR.
SUN TIME, HOURS
140
130
120
110
100
90
80
70
350
300
250
200
150
100
50
0730
0830
0930
1030
1130
1230
1330
TEST II
RADIATION
TEST I
ROOM AIR TEMPERATURE
TEST III
TEST IV
COOLING SYSTEM TURNED ON

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FIG. 2

FIG. 3

GROUP 2

TEST OF REFRIGERATED AMBULANCE WITH DESERT CONDITIONS AND FIVE PATIENTS IN COMPARTMENT

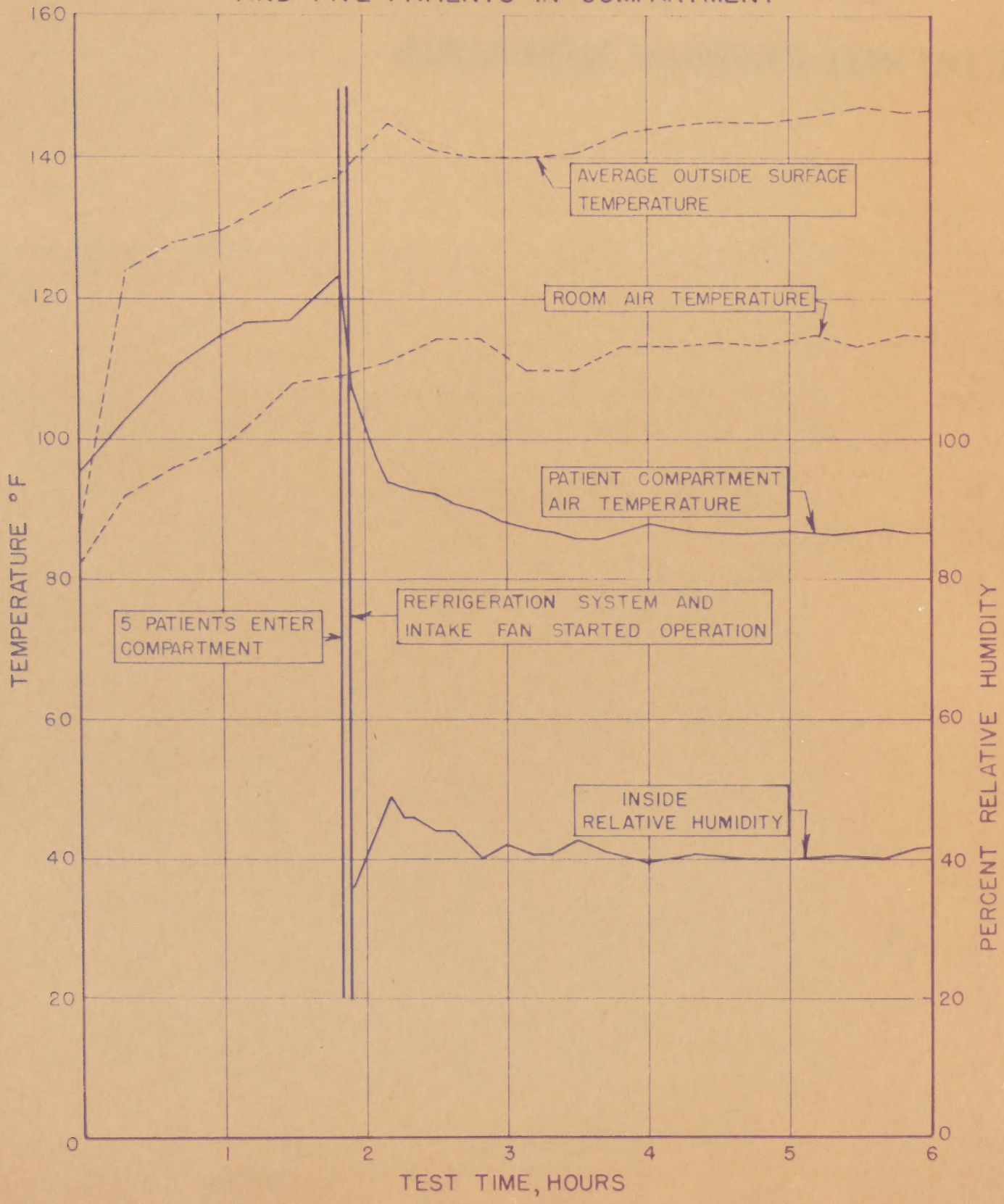

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FIG. 3